Executive Summary

Purpose

Lawrence Livermore National Laboratory (LLNL) prepared this Site-Wide Feasibility Study (SWFS) for the Site 300 experimental test facility near Tracy, California, in accordance with the terms outlined in the Federal Facility Agreement (FFA). This SWFS will lead to a Proposed Plan, in preparation for an Interim Record of Decision (ROD). The FFA was negotiated among the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), California Department of Toxic Substances Control (DTSC), and California Regional Water Quality Control Board (RWQCB). The FFA provides the framework for conducting site cleanup and preparing necessary regulatory documents. This SWFS complies with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). The SWFS, along with the previously conducted remedial investigations, forms the basis for evaluating and selecting technologies for remediation of contaminants at Site 300. The Feasibility Study process involves six steps:

1. Identifying Remedial Action Objectives (RAOs) based on Applicable or Relevant and Appropriate Requirements (ARARs).
2. Identifying general response actions.
3. Identifying potential remedial technologies and associated process options.
4. Screening various technologies and process options based on their applicability, effectiveness, implementability, and cost.
5. Assembling the selected technologies into modules to address contaminants, and combining the modules into alternative remedies.
6. Analyzing the remedial alternatives using the U.S. EPA evaluation criteria.

Remediation modules are presented for all contaminants of concern (COCs) for which sufficient data exist to support developing conceptual remedial designs. This approach considers all RAOs, which are not based strictly on risk or hazard. The modules are not designed to stand alone. For each specific operable unit (OU) or release site, modules have been combined to form potential remedies. The remedies are then assembled into sets of remedial alternatives and evaluated. The SWFS does not identify preferred remedies. The Draft Site-Wide Proposed Plan (which will follow the SWFS), will propose, describe, and justify a preferred alternative remedy for each OU or release site.

After public and regulatory review and comment on the Proposed Plan, DOE will present the selected remedies in an Interim ROD. The Interim ROD will not set cleanup standards; they will be set in the Final ROD. An Interim ROD is intended to allow remediation to commence as soon as possible, while collecting additional information. Data on the effectiveness of remediation technologies relevant to decisions of final cleanup concentrations can be developed without adversely impacting the early decisions to begin the cleanup processes. Information developed

through more detailed source characterization and observation of how aquifers react to the interim response actions will be considered in choosing the final cleanup standards, which are set in the Final ROD, scheduled for 2007.

No ground water contaminated as a result of Site 300 activities is currently used for human consumption. Risk from exposure to soil and soil vapor contamination is controlled through site access control and site safety procedures.

The DOE retains a number of technologies (such as those for *ex situ* treatment of extracted ground water or soil vapor) for consideration at a later stage in the remedial design process, but does not specifically include these technologies in the modules or alternatives evaluated in detail.

Site Description

Chapter 1 contains background information, including the nature and extent of contamination, identification of COCs, and summaries of the baseline human health and ecological risk assessments.

LLNL Site 300 is a DOE experimental test facility operated by the University of California. The facility is located in the eastern Altamont Hills about 13 miles southeast of the main Laboratory site in Livermore and 8.5 miles southwest of Tracy. Site 300 is primarily a high-explosives (HE) test facility supporting the LLNL weapons program in research, development, and testing associated with weapons components.

Prior to August 1990, investigations of environmental contamination at Site 300 were conducted under the oversight of the California RWQCB-Central Valley Region. In August 1990, EPA placed Site 300 on the National Priorities List (NPL). Since then, all investigations have been conducted in accordance with CERCLA, under the oversight of the three supervising regulatory agencies: U.S. EPA, RWQCB, and DTSC.

Site 300 has been divided into eight OUs based on the specific location and nature and extent of contamination. Contaminants of concern are shown in Figure Ex-1. The extent of ground water contamination is shown in Figure Ex-2. Described below are the eight OUs and the types of contamination in each.

1. General Services Area (GSA)—OU 1. Contamination resulted from past solvent disposal, causing volatile organic compound (VOC) contamination of soil, bedrock, and ground water. A ROD for the GSA OU was signed in 1997. Ground water and vadose zone remediation is ongoing as described in the Remedial Design report for the GSA (Rueth et al., 1998). The SWFS incorporates the GSA OU CERCLA documents by reference.
2. Building 834—OU 2. Past spills of trichloroethylene (TCE) and other VOCs from release sites at the core of the Building 834 complex resulted in contamination of the vadose zone and a perched water-bearing unit. The deeper regional aquifer has not been affected. Dense non-aqueous phase liquids (DNAPLs) and light non-aqueous phase liquids (LNAPLs) are present in ground water. Other contaminants of concern in ground water include nitrate and tetra-butyl-orthosilicate/tetra-kis-2-ethylbutylorthosilicate (TBOS/TKEBS). Ground water and vadose zone remediation is ongoing, as is innovative technology testing.

3. Landfill Pit 6—OU 3. From 1964 to 1973, approximately 1,900 cubic yards of waste were placed in nine unlined debris trenches and animal pits at Landfill Pit 6. The material buried included laboratory and shop debris and biomedical waste. Plumes of VOCs and tritium in ground water originated from the landfill. VOC concentrations in ground water have been declining since 1989. Perchlorate and nitrate have also been detected in ground water. The landfill was capped as a removal action in 1997 to prevent infiltrating precipitation from further leaching contaminants from the buried waste.

4. HE Process Area—OU 4. Surface spills occurred at the drum storage and dispensing area for the former Building 815 steam plant, where TCE was used to clean pipelines. These spills resulted in the release of TCE and other VOCs to the ground surface and contamination of the ground water and the vadose zone. HE compounds, nitrate, and perchlorate have also been detected in ground water and are likely the result of wastewater discharges to former unlined rinsewater lagoons. HE compounds have also been detected in surface soil and the vadose zone. The lagoons were closed in 1989. In addition, VOCs, nitrate, and perchlorate have been detected in ground water in the vicinity of the former HE Burn Pits. The Burn Pits were capped under RCRA in 1998.

5. Building 850/Pits 3 & 5—OU 5. Contamination in this OU emanates from the Building 850 Firing Table and from Landfill Pits 3 and 5. Tritium is the primary contaminant in ground water. TCE and 1,1-dichloroethylene (1,1-DCE) have been detected downgradient of Landfill Pit 5. Uranium isotope signatures characteristic of depleted uranium (uranium with isotopes other than 238 extracted, leaving almost entirely uranium-238) have also been identified downgradient of Landfill Pits 3 and 5 and Building 850. Other ground water contaminants include nitrate and perchlorate. This OU also addresses uranium-238 contamination in ground water from Landfill Pit 7. Landfill Pits 1, 4, 7 and a portion of Landfill Pit 3 were capped and closed under RCRA in 1992. Polychlorinated biphenyl (PCB)-bearing shrapnel from explosive experiments was identified in the vicinity of the Building 850 Firing Table and was removed in October 1998. PCBs, chlorinated dibenzodioxins and dibenzofurans, high-melting explosives (HMX), metals, and uranium-238 have been detected in soil in the vicinity of this firing table. Landfill Pit 2 operated from 1956 to 1960 and incorporated firing table waste from Buildings 801 and 802. No contaminants have been released from the landfill. Tritium detected in ground water in the vicinity of Pit 2 may originate upgradient, at the Building 850 area.

6. Building 854—OU 6. TCE was used at Building 854 as a heat-exchange fluid. Site characterization indicates significant vadose zone and ground water VOC contamination. Nitrate, perchlorate, tritium, and uranium-238 have also been detected in ground water. PCBs, metals, HMX, and tritium have been detected in surface soil. TCE-contaminated soil was excavated in 1983 from the vicinity of the Building 854H drain outfall, and surface soil was removed at the northeast corner of Building 854F. The TCE brine systems were removed in 1989.

7. Building 832 Canyon—OU 7. Facilities in this OU were used to test the stability of weapons and weapons components under various environmental conditions. Vadose zone and ground water contamination was identified emanating from the Building 830 and Building 832 release sites. Contaminants released to the subsurface were primarily VOCs, although nitrate and perchlorate have also been detected in ground water. Nitrate and

HMX have been detected in the subsurface soil. HMX was also reported in surface soil. A treatability study is underway to evaluate ground water and soil vapor extraction.

8. Site 300 Release Sites—OU 8. This OU covers all other release sites not included in other OUs. These release sites are:

   – Building 801 Firing Table: This firing table was used for explosives testing. Dispersal of firing table debris has resulted in metal and uranium-238 contamination of surface soil. No contaminants from the firing table have been detected in ground water. Gravel and surface soil beneath the firing table were removed in 1988. Use of this firing table was discontinued in 1998, and additional material was excavated. Landfill Pit 8, located adjacent to the Building 801 firing table, received firing table debris prior to 1974, when a cover was installed. There is no evidence of contaminant releases from Pit 8.

   – Building 801 Dry Well: Low-level VOC contamination of ground water and the vadose zone resulted from waste fluid discharges to a dry well beneath Building 801D. This dry well was decommissioned and filled with concrete in 1981.

   – Building 802 Firing Table: This firing table was used for explosives testing. Dispersal of firing table debris has resulted in tritium contamination in surface soil. Leaching of contaminants from the firing table gravel resulted in the contamination of subsurface soil with tritium. The gravel from the firing table was removed in 1988. Tritium migration modeling indicates that there is no significant risk or hazard associated with this contaminant, and no potential impact to ground water. No contaminants have been detected in ground water. The Building 802 Firing Table is not addressed as a release site in the SWFS.

   – Building 833 Disposal Lagoon: TCE was used as a heat-exchange fluid in the Building 833 area. Surface discharge of waste fluids containing TCE occurred through spills, building washdown, rinsewater from the test cell and settling basin, and rinsewater disposal in a disposal lagoon adjacent to Building 833. As a result, VOCs have been detected in subsurface soil and ephemeral perched ground water. A monitoring-only remedy was accepted by the regulatory agencies at a December 1993 meeting of the Remedial Project Managers.

   – Building 845 Firing Table: This firing table was used until 1963 to conduct explosives experiments that occasionally used tritium and depleted uranium. As a result, subsurface soil is contaminated with uranium-238, tritium, and HMX. In 1988, firing table gravel and soil from the firing table berm was removed. Landfill Pit 9 was used prior to 1968 for the disposal of debris generated at the Building 845 Firing Table. There is no evidence of contaminant releases from Pit 9.

   – Building 851 Firing Table: This firing table is used to conduct experimental high explosives research. These experiments resulted in the release of tritium, uranium-238, and metals to surface soil and VOCs and uranium-238 to subsurface soil and rock. Low concentrations of VOC and uranium-238 have been identified in ground water. Firing table gravel is replaced periodically, most recently in 1998.

Four potential release sites (Building 812 Firing Table, Building 812 Dry Well, Building 865 Advanced Test Accelerator, and the Sandia Test Site) are scheduled for further investigation work and are not addressed in this SWFS.

ARARs and Remedial Action Objectives

RAOs are specific goals for protecting human health and the environment. In Chapter 2, RAOs are developed by integrating health-protective requirements, criteria, or limitations that are determined to be ARARs with the results of the remedial investigations, including the human and ecological risk assessments. The National Contingency Plan specifies that RAOs be developed to address: (1) contaminants of concern, (2) media of concern, (3) potential exposure pathways, and (4) preliminary remediation levels.

The SWFS assembles General Response Actions and technologies into implementable alternatives that will satisfy the RAOs.

The RAOs are as follows:

For Human Health Protection:

- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above the State and Federal Maximum Contaminant Levels (MCLs), and RWQCB Water Quality Objectives if applicable.
- Prevent human incidental ingestion and direct dermal contact with contaminants in surface soil that pose an excess cancer risk greater than 10^{-6} or a Hazard Index (HI) greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.
- Prevent human inhalation of VOCs and tritium volatilizing from subsurface soil to air that pose an excess cancer risk greater than 10^{-6} or a HI greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.
- Prevent human inhalation of contaminants (VOCs and tritium) volatilizing from surface water to air that pose an excess cancer risk greater than 10^{-6} or a HI greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.
- Prevent human inhalation of contaminants bound to resuspended surface soil particles that pose an excess cancer risk greater than 10^{-6} or a HI greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.
- Prevent human exposure to contaminants of concern that pose a cumulative excess cancer risk (all carcinogens) greater than 10^{-4} and/or a cumulative HI greater than one (all noncarcinogens).

For Environmental Protection:

- Restore water quality, at a minimum, to water quality objectives that are protective of beneficial uses within a reasonable timeframe. Maintain existing water quality that

complies with water quality objectives. This will apply to both individual and multiple constituents that have additive toxicological or carcinogenic effects.

- Ensure ecological receptors important at the individual level of organization (listed threatened or endangered, State of California species of special concern) do not reside in areas where relevant ecological hazard indices exceed 1.
- Ensure existing contaminant conditions do not change so as to threaten wildlife populations and vegetation communities.

There is no RAO for human health protection/ARAR compliance for ingestion of surface waters (springs) because there is not a complete exposure pathway for ingestion of surface waters by humans at Site 300. Humans do not drink water from springs at the site. In addition, the springs in which contaminants are currently detected do not produce a sufficient quantity of water to be used as a water supply (greater than 200 gal/day). Since there is not considered to be an exposure route for human ingestion of surface water at the site, an RAO was not developed for this pathway.

Identification and Screening of General Response Actions and Remedial Technologies

In Chapter 3, we evaluate and screen a number of response actions and remedial technologies capable of achieving the RAOs established in Chapter 2.

General Response Actions are measures that can potentially achieve the RAOs, and can mitigate potential exposure to, control the migration of, and/or remediate COCs at the site. Eight General Response Actions are identified for OUs or release sites at Site 300.

1. No further action.
2. Risk and hazard management.
3. Monitored natural attenuation.
4. Extraction and *ex situ* treatment.
5. *In situ* treatment.
6. Containment.
7. Hydraulic control.
8. Removal and disposal.

Description of Remediation Modules

In Chapter 4, the retained general response actions and technologies are assembled into modules designed to address the contaminants and media of concern and to meet the RAOs. For each OU, and for each of the release sites in OU 8, we have developed from 3 to 11 remediation modules; one or more of these modules will constitute a potential remedy for that OU. In Chapter 6, the modules are combined to assemble a set of alternative remedies. A summary of the remedial modules for all OUs is presented as Table Ex-1. A more detailed summary of how all COCs are addressed by the modules is presented as Table Ex-2.

Remediation modules are presented for release sites when triggered by any of the following four criteria:

1. Concentrations of COCs in ground water or surface water are currently above background.
2. Contaminants are present in the vadose zone, surface soil, or buried waste at concentrations sufficient to potentially contaminate, or to continue to contaminate, ground water at measurable concentrations above background.
3. A baseline human health risk greater that 10^{-6}, or a HI greater than 1 is present, either from a single pathway and contaminant, or additively as the sum of risks or hazards present from all pathways and contaminants. Ingestion of ground water is not included in this criterion because inclusion of an active ground water remediation module is triggered by the first criterion, regardless of risk or hazard.
4. The ecological HI exceeds 1 for the San Joaquin kit fox.

The remediation modules are not designed to stand alone. The modules are conceptual in scope, and are intended to allow comparison of remedial strategies, rather than to provide logistical or design information. Remedial modules are presented for all COCs for which sufficient data exist to support developing conceptual remedial designs. The DOE retains a number of technologies, including innovative approaches and those for *ex situ* treatment of extracted ground water or soil vapor, for consideration at a later stage in the remedial design process but does not specifically include these technologies in the modules in Chapter 4.

In the process of developing remediation modules, the need for additional characterization or data collection has been identified in some areas. Descriptions and cost estimates for these activities are included in the modules, as necessary.

The following are the specific remedial technologies included as modules:

- Monitoring.
- Risk and hazard management.
- Monitored natural attenuation.
- Ground water and/or soil vapor extraction and treatment.
- Ground water interception and diversion.
- Enhanced *in situ* bioremediation.
- *In situ* reactive barrier.
- Excavation of soil and bedrock underlying firing tables and removal of adjacent surface soil.
- Buried waste characterization with contingent monitoring, landfill capping, or excavation.

Evaluation of Remediation Modules

Chapter 5 presents an analysis of the remediation modules developed in Chapter 4. The modules are evaluated in the context of their applications at Site 300, for: protectiveness of human health and the environment; ability to meet ARARs; effectiveness; the ability to reduce volume,

mobility or toxicity; implementability; and cost. This information assists in the formal review of remedial alternatives against EPA criteria in Chapter 7.

Description of Remedial Alternatives

Chapter 6 presents the remedial alternatives that were assembled to address subsurface COCs in the Site 300 OUs. Each of the remedial alternatives is developed from the retained technologies described in Chapter 3 and modules presented in Chapter 4.

To develop these remedial alternatives, retained technologies and modules based on applicability, implementability, effectiveness, cost, site- and OU-specific requirements, and best professional judgment were incorporated.

Two or more alternatives are presented for each OU. In OU 5 (Building 850/Pits 3 & 5) and OU 8 (Building 833/Building 845/Building 851), where numerous release sites are present, alternatives are presented by release site subarea. Table EX-3 presents the alternatives by OU and subarea. The major components and objectives of each alternative are described, and costs are presented.

In order to expedite the FS process, presumptive remedies and/or technologies were incorporated where appropriate. Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. The objective of EPA's presumptive remedy program is to "use the program's past experience to streamline site investigation and speed up selection of cleanup actions." Presumptive remedies were identified for the Building 854 OU and the Building 832 Canyon OU. Therefore, only two alternatives, a no action alternative required by EPA guidance, and the presumptive remedy, are presented for these OUs.

Remediation-specific details, such as the number and location of extraction wells used for a pump-and-treat alternative, are presented in this SWFS for purposes of costing and strategy presentation. The actual site- and technology-specific details will be based on additional data and design criteria presented in the Remedial Design documents.

Detailed Evaluation of Remedial Alternatives

Chapter 7 presents a detailed analysis of the remedial alternatives developed in Chapter 6 for each of the Site 300 OUs.

The (NCP) identifies nine criteria to be used in the detailed analysis of alternatives:

1. Overall protection of human health and the environment.
2. Compliance with ARARs.
3. Long-term effectiveness and permanence.
4. Reduction of toxicity, mobility, and volume through treatment.
5. Short-term effectiveness.
6. Implementability.

7. Cost.
8. State acceptance.
9. Community acceptance.

For each alternative, an evaluation of how the alternative addresses the first seven EPA criteria specified by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). In addition, a comparative evaluation of the characteristics of each alternative against the other alternatives with respect to the first seven criteria is presented for each OU.

The California Department of Toxic Substances Control and Regional Water Quality Control Board-Central Valley Region will review and comment on this document. Analysis of technical and administrative concerns that these agencies may have regarding each of the alternatives will be addressed. The State agencies will participate in the selection of the final remedies and cleanup goals for Site 300 which will be codified in the Site 300 Interim ROD.

A Public Workshop will be held after the Final SWFS is published to receive public input on the proposed remedial alternatives for the Site 300 OUs. A summary of the remedial alternatives and the preferred remedies will be published in the Proposed Plan for the remediation of Site 300. A Public Meeting will be held during the 30-day comment period for the Proposed Plan to received formal comments from the public. Public comments will be considered in the selection of the final remedies for Site 300 Interim ROD. Public comments made during the Public Meeting and 30-day comment period will be addressed in writing in the Responsiveness Summary of the Site 300 Interim ROD.

Environmental Considerations

Section II.E of the DOE Secretarial Policy Statement on the National Environmental Policy Act (NEPA) requires that when DOE remedial actions under CERCLA trigger the procedures set forth in NEPA, the procedural and documentation requirements of NEPA and CERCLA are to be integrated. Integration is to be accomplished by conducting the NEPA and CERCLA environmental planning and review procedures concurrently to avoid duplication, conflicting analysis, and delays in implementing remedial action on procedural grounds. In the past, the primary instrument for this integration was the Remedial Investigation/Feasibility Study (RI/FS) process, supplemented as needed to meet the requirements of NEPA. Each remedial alternative was reviewed and evaluated for potential environmental impacts of the remedial alternatives under NEPA.

However, given the scope and complexity of the remedial alternative presented in this SWFS (incorporating over 60 modules), the DOE and the regulatory agencies agreed to conduct the NEPA evaluation at a later date. The NEPA evaluation is now underway and will be issued in a separate report prior to the Draft Interim ROD. If the NEPA review identifies any unacceptable impact(s) associated with the selected remedy, appropriate actions will be taken either to modify the remedy or provide impact mitigation. NEPA evaluation results will be presented in the Site-Wide Interim Record of Decision. The NEPA evaluation will provide additional information necessary to evaluate potential environmental impacts of each remedy under NEPA, in compliance with all requirements.

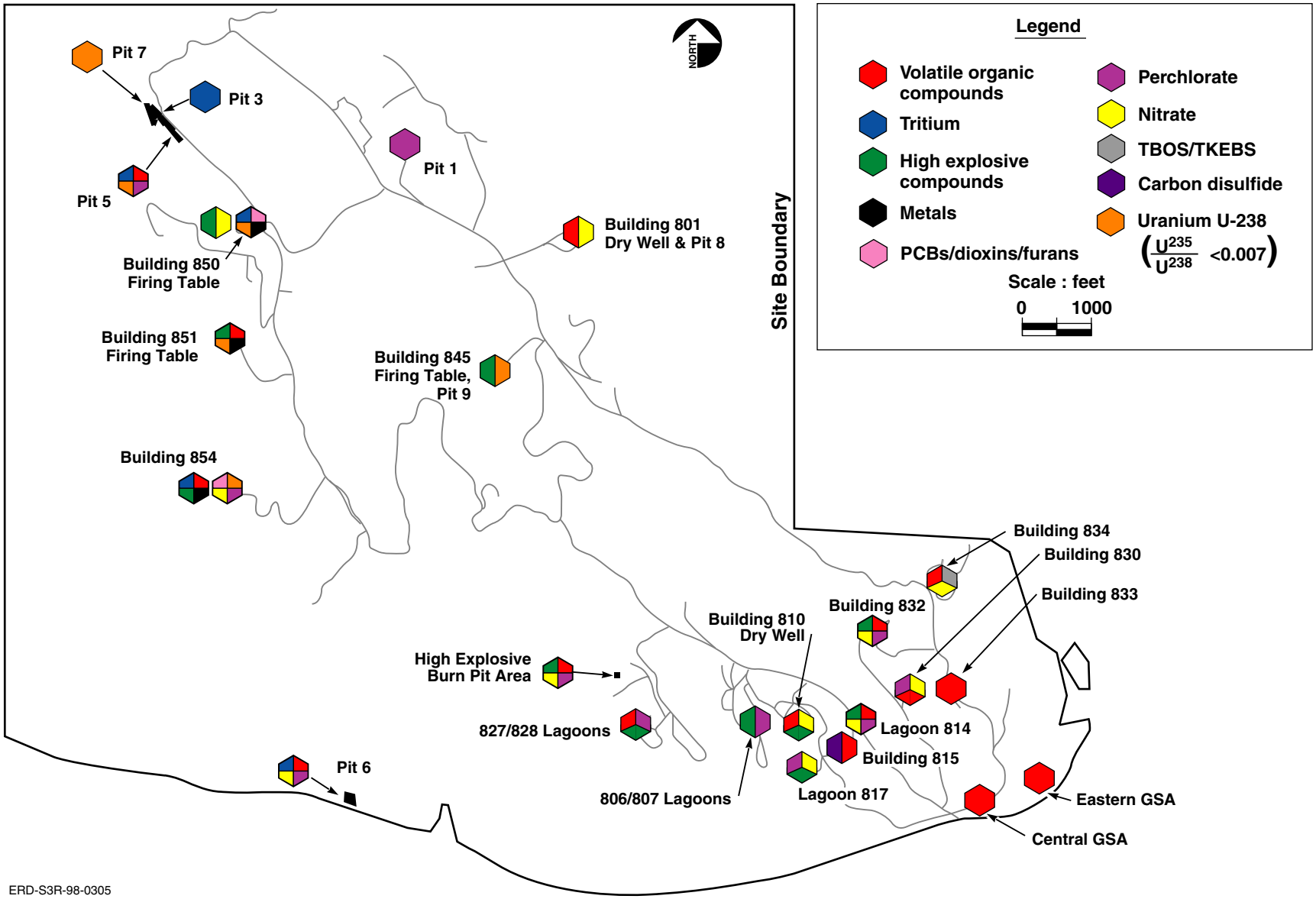

Figure EX-1. Contaminants of concern at LLNL Site 300.

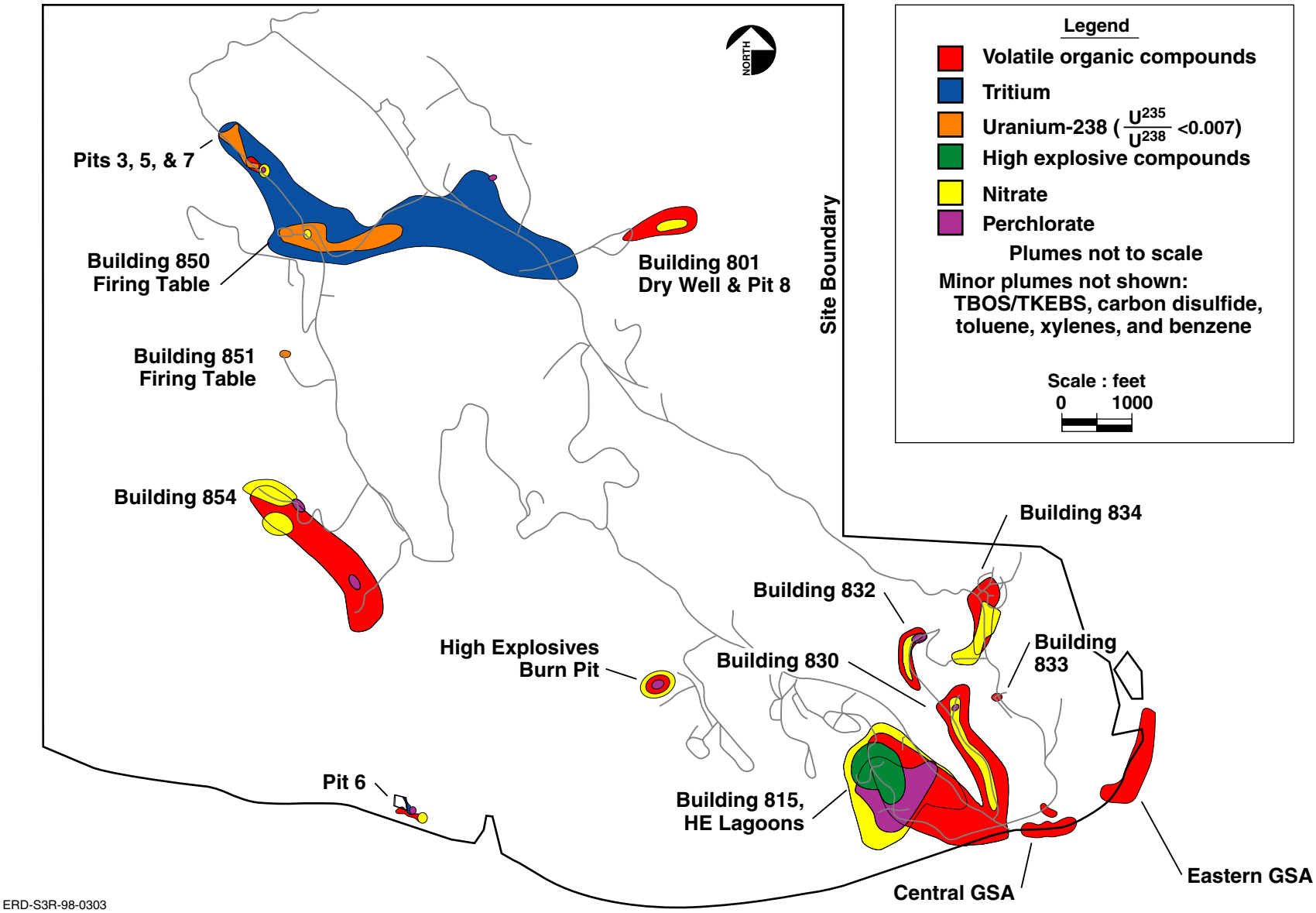

Figure EX-2. Extent of ground water contamination at LLNL Site 300.

Table Ex-1. Summary of remediation modules for the LLNL Site 300 Site-Wide Feasibility Study.

Building 834 (OU 2)	Pit 6 (OU 3)	HE Process Area (OU 4)	Landfill Pit 7 Complex (OU 5)	Building 850 Firing Table (OU 5)	Landfill Pit 2 (OU 5)
Module A: No further action Module B: Monitoring Module C: Risk and hazard management Module D: Ground water and soil vapor extraction and treatment of VOCs, TBOS/TKEBS, and nitrate Module E: Enhanced *in situ* bioremediation of VOCs	Module A: No further action Module B: Monitoring Module C: Risk and hazard management Module D: Monitored natural attenuation of VOCs and tritium in ground water Module E: Ground water extraction and treatment of VOCs and perchlorate	Module A: No further action Module B: Monitoring Module C: Risk and hazard management Module D: Contaminant migration control by ground water extraction and treatment of VOCs and nitrate at the leading edge of the Building 815 TCE plume Module E: Ground water extraction and treatment of VOCs, HE compounds, nitrate, and perchlorate released from Building 815 and the high explosives rinsewater lagoons Module F: Ground water extraction and treatment of VOCs, nitrate, and perchlorate released from the HE Burn Pit	Module A: No further action Module B: Monitoring Module C: Risk and hazard management Module D: Monitored natural attenuation of tritium in ground water Module E: Ground water extraction and treatment of VOCs Module F: Ground water extraction and treatment of uranium and nitrate Module G: Control migration of uranium-238 in ground water using *in situ* reactive permeable barriers Module H: Waste characterization with contingent monitoring, capping, or excavation of Landfill Pits 3 and 5	Module A: No further action Module B: Monitoring Module C: Risk and hazard management Module D: Monitored natural attenuation of tritium in ground water and surface water Module E: Ground water extraction and treatment of uranium and nitrate Module F: Control migration of uranium-238 in ground water using *in situ* reactive permeable barriers Module G: Excavation of contaminated soil and bedrock underlying the Building 850 firing table, removal of the contaminated sandpile, and removal of contaminated soil adjacent to the firing table	Module A: No further action Module B: Monitoring Module C: Waste characterization with contingent monitoring, capping, or excavation of Landfill Pit 2

Building 854 (OU 6)	Building 832 Canyon (OU 7)	Building 801, Landfill Pit 8 (OU 8)	Building 833 (OU 8)	B845 Firing Table, Pit 9 (OU 8)	Building 851 Firing Table (OU 8)
Module A: No further action Module B: Monitoring Module C: Risk and hazard management Module D: Ground water and soil vapor extraction and treatment of VOCs and nitrate	Module A: No further action Module B: Monitoring Module C: Risk and hazard management Module D: Ground water and soil vapor extraction and treatment of VOCs, perchlorate, and nitrate at Building 832 Module E: Ground water and soil vapor extraction and treatment of VOCs, perchlorate, and nitrate at Building 830 Module F: Downgradient ground water extraction using a siphon with *ex situ* treatment of VOCs by iron filings	Module A: No further action Module B: Monitoring Module C: Waste characterization with contingent monitoring, capping, or excavation of Landfill Pit 8	Module A: No further action Module B: Monitoring Module C: Risk and hazard management Module D: Ground water and soil vapor extraction and treatment of VOCs	Module A: No further action Module B: Monitoring Module C: Waste characterization with contingent monitoring, capping, or excavation of Landfill Pit 9	Module A: No further action Module B: Monitoring Module C: Ground water extraction and treatment of uranium

Table Ex-2. Remediation modules for all contaminants of concern.

Contaminant	Surface soil	Subsurface soil	Ground water	Surface water
Building 834				
VOCs		Risk and hazard management (C) Soil vapor extraction (D)	Monitoring (B) Risk and hazard management (C) Ground water extraction (D) In situ bioremediation (E)	
TBOS/TKEBS			Monitoring (B) Risk and hazard management (C) Ground water extraction (D)	
Nitrate			Monitoring (B) Risk and hazard management (C) Ground water extraction (D)	
Landfill Pit 6				
VOCs			Monitoring (B) Risk and hazard management (C) Monitored natural attenuation (D) Ground water extraction (E)	Monitoring (B) Risk and hazard management (C)
Tritium			Monitored natural attenuation (D)	
Nitrate			Monitoring (B)	
Perchlorate			Monitoring (B) Ground water extraction (E)	
HEPA Building 815				
VOCs		Risk and hazard management (C)	Monitoring (B) Risk and hazard management (C) Ground water extraction (D, E)	Monitoring (B) Risk and hazard management (C)
Carbon disulfide			Monitoring (B) Risk and hazard management (C)	
HE Rinsewater Lagoons				
VOCs		No further action (A)		
RDX, HMX, 4-Amino-2,6-dinitrotoluene	No further action (A)	No further action (A)	Monitoring (B) Risk and hazard management (C) Ground water extraction (E)	
Nitrate			Monitoring (B) Risk and hazard management (C) Ground water extraction (E)	
Perchlorate			Monitoring (B) Risk and hazard management (C) Ground water extraction (E)	
HE Burn Pits				
VOCs		No further action (A)	Monitoring (B) Risk and hazard management (C) Ground water extraction (F)	
RDX, HMX		No further action (A)		
Nitrate			Monitoring (B) Risk and hazard management (C) Ground water extraction (F)	
Perchlorate			Monitoring (B) Risk and hazard management (C) Ground water extraction (F)	
Landfill Pit 7 Complex				
VOCs			Monitoring (B) Risk and hazard management (C) Ground water extraction (E)	
Nitrate			Monitoring (B) Ground water extraction (F)	
Perchlorate			Monitoring (B) Risk and hazard management (C) Ground water extraction (F)	
Tritium	No further action (A)	Risk and hazard management (C) Landfill monitoring, capping, or excavation (H)	Monitored natural attenuation (D)	
Uranium-238	No further action (A)	Reactive permeable barrier (G) Landfill monitoring, capping, or excavation (H)	Monitoring (B) Risk and hazard management (C) Ground water extraction (F) Reactive permeable barrier (G)	
Building 850 Firing Table				
Metals	Surface soil removal (G)			
HMX	Surface soil removal (G)			
Nitrate			Monitoring (B) Risk and hazard management (C) Ground water extraction (E)	

Table Ex-2. Remediation modules for all contaminants of concern. (Cont. Page 2 of 2)

Contaminant	Surface soil	Subsurface soil	Ground water	Surface water
Building 850 Firing Table (cont.)				
PCBs	Risk and hazard management (C) Surface soil removal (G)			
Tritium		Firing table excavation (G)	Monitoring (B) Risk and hazard management (C) Monitored natural attenuation (D)	Monitored natural attenuation (D)
Uranium-238	Surface soil removal (G)	Firing table excavation (G)	Monitoring (B) Risk and hazard management (C) Ground water extraction (E) Reactive permeable barrier (F)	
Building 854 OU				
VOCs		Risk and hazard management (C) Soil vapor extraction (D)	Monitoring (B) Risk and hazard management (C) Ground water extraction (D)	
Metals	No further action (A)			
Nitrate			Monitoring (B) Risk and hazard management (C) Ground water extraction (D)	
PCBs	Risk and hazard management (C)			
HMX	No further action (A)			
Perchlorate			Monitoring (B) Risk and hazard management (C)	
Tritium	No further action (A)		Monitoring (B)	
Uranium-238			Monitoring (B) Risk and hazard management (C) Ground water extraction (D)	
Building 830				
VOCs		Risk and hazard management (C) Soil vapor extraction (E)	Monitoring (B) Risk and hazard management (C) Ground water extraction (E, F)	Monitoring (B) Risk and hazard management (C)
Nitrate		No further action (A)	Monitoring (B) Risk and hazard management (C) Ground water extraction (E, F)	
HMX	No further action (A)			
Perchlorate			Monitoring (B) Risk and hazard management (C) Ground water extraction (E)	
Building 832				
VOCs		Soil vapor extraction (D)	Monitoring (B) Risk and hazard management (C) Ground water extraction (D)	
Nitrate		No further action (A)	Monitoring (B) Risk and hazard management (C) Ground water extraction (D)	
HMX		No further action (A)		
Perchlorate			Monitoring (B) Risk and hazard management (C) Ground water extraction (D)	
Building 801, Landfill Pit 8				
VOCs		No further action (A)	Monitoring (B)	
Nitrate			Monitoring (B)	
Building 833				
VOCs		Risk and hazard management (C) Soil vapor extraction (D)	Monitoring (B) Risk and hazard management (C) Ground water extraction (D)	
Building 845 Firing Table, Landfill Pit 9				
HMX		No further action (A) Landfill monitoring, capping, or excavation (C)		
Uranium-238		No further action (A) Landfill monitoring, capping, or excavation (C)		
Building 851 Firing Table				
VOCs		No further action (A)	Monitoring (B)	
RDX	No further action (A)			
Metals	No further action (A)			
Uranium-238	No further action (A)	No further action (A)	Monitoring (B) Ground water extraction (C)	

Table Ex-3. Remedial Alternatives for the Site 300 Operable Units.

Remedial Alternatives for Building 834 (OU 2)		
Alternative 1	**Alternative 2**	**Alternative 3**
No further action for all contaminants and media of concern. Previous interim actions: 1) Excavation of VOC contaminated soil (1983). 2) Surface water drainage diversion (1998). 3) Ongoing soil vapor and ground water extraction since 1995. Total Estimated Cost: $0	Module B: Monitoring of ground water. Module C: Exposure control through risk and hazard management. Module D: Ground water and soil vapor extraction and treatment of VOCs, TBOS/TKEBS, and nitrate (ongoing since 1995). Previous interim actions: 1) Excavation of VOC contaminated soil (1983). 2) Surface water drainage diversion (1998). 3) Ongoing soil vapor and ground water extraction since 1995. Total Estimated Cost: $12,095,000	Module B: Monitoring of ground water. Module C: Exposure control through risk and hazard management. Module D: Ground water and soil vapor extraction and treatment of VOCs, TBOS/TKEBS, and nitrate (ongoing since 1995). Module E: Enhanced *in situ* bioremediation of VOCs. Previous interim actions: 1) Excavation of VOC contaminated soil (1983). 2) Surface water drainage diversion (1998). 3) Ongoing soil vapor and ground water extraction since 1995. Total Estimated Cost: $14,504,000

Table Ex-3. Remedial Alternatives for the Site 300 Operable Units. (Cont. Page 2 of 9)

Remedial Alternatives for the Pit 6 Landfill (OU 3)		
Alternative 1	**Alternative 2**	**Alternative 3**
No further action for all contaminants and media of concern. Previous interim actions: 1) Exhumed waste containing uranium-238 (1971). 2) Capped landfill as a CERCLA removal action (1997). Total Estimated Cost: $0	Module B: Monitoring of ground and surface water. Module C: Exposure control through risk and hazard management. Module D: Monitored natural attenuation of VOCs and tritium in ground water. Previous interim actions: 1) Exhumed waste containing uranium-238 (1971). 2) Capped landfill as a CERCLA removal action (1997). Total Estimated Cost: $2,377,000	Module B: Monitoring of ground and surface water. Module C: Exposure control through risk and hazard management. Module D Monitored natural attenuation of tritium in ground water. Module E: Ground water extraction and treatment of VOCs and perchlorate. Previous interim actions: 1) Exhumed waste containing uranium-238 (1971). 2) Capped landfill as a CERCLA removal action (1997). Total Estimated Cost: $5,939,000

Table Ex-3. Remedial Alternatives for the Site 300 Operable Units. (Cont. Page 3 of 9)

Remedial Alternatives for the HE Process Area (OU 4)	
Alternative 1	**Alternative 2**
No further action for all contaminants and media of concern. Previous interim actions: 1) Closed HE Rinsewater Lagoons under RWQCB (1985-1989). 2) Sealed and abandoned water-supply wells 4 (1990) and 6 (1989). 3) Capped HE Burn Pits under RCRA (1998). Total Estimated Costs: $0	Module A: No further action for (1) VOCs in subsurface soil/rock at the HE rinsewater lagoon release sites, and (2) VOCs and HMX/RDX in subsurface soil/rock at the HE burn pit release site. Module B: Monitoring of ground and surface water. Module C: Exposure control through risk and hazard management. Module D: Ground water extraction and treatment of VOCs and nitrate at the leading edge of the B815 TCE plume. Module E: Ground water extraction and treatment of VOCs, HE compounds, nitrate, and perchlorate released from B815 and HE rinsewater lagoons. Module F: Ground water extraction and treatment of VOCs, nitrate, and perchlorate released from the HE Burn Pit. Previous interim actions: 1) Closed HE Rinsewater Lagoons under RWQCB (1985-1989). 2) Sealed and abandoned water-supply wells 4 (1990) and 6 (1989). 3) Capped HE Burn Pits under RCRA (1998). Total Estimated Cost: $27,621,000

Table Ex-3. Remedial Alternatives for the Site 300 Operable Units. (Cont. Page 4 of 9)

Remedial Alternatives for the Pit 7 Complex including Pits 3, 4, 5, and 7 (OU 5)			
Alternative 1	**Alternative 2a**	**Alternative 2b**	**Alternative 3**
No further action for all contaminants and media of concern. Previous interim actions: 1) Capped Pits 4 and 7 under RCRA (1992). Total Estimated Cost: $0	Module A: No further action for tritium and uranium in surface soil at Pits 3 and 5. Module B: Monitoring of ground water. Module C: Exposure control through risk and hazard management. Module D: Monitored natural attenuation of tritium and uranium-238 in ground water. (Modified module D) Module H: Waste characterization with contingent monitoring, capping, and/or excavation of Pits 3 and 5. Previous interim actions: 1) Capped Pits 4 and 7 under RCRA (1992). Total Estimated Cost: $50,282,000	Module A: No further action for tritium and uranium in surface soil at Pits 3 and 5. Module B: Monitoring of ground water. Module C: Exposure control through risk and hazard management. Module D: Monitored natural attenuation of tritium and uranium-238 in ground water. (Modified module D) Module G: Control migration of uranium-238 in ground water using *in situ* reactive permeable barriers. Module H: Waste characterization with contingent monitoring, capping, and/or excavation of Pits 3 and 5. Previous interim actions: 2) Capped Pits 4 and 7 under RCRA (1992). Total Estimated Cost: $54,623,000	Module A: No further action for tritium and uranium in surface soil at Pits 3 and 5. Module B: Monitoring of ground water. Module C: Exposure control through risk and hazard management. Module D: Monitored natural attenuation of tritium in ground water. Module E: Ground water extraction and treatment of VOCs. Module F: Ground water extraction and treatment of uranium-238 and nitrate. Module G: Control migration of uranium-238 in ground water using *in situ* reactive permeable barriers. Module H: Waste characterization with contingent monitoring, capping, and/or excavation of Pits 3 and 5. Previous interim actions: 1) Capped Pits 4 and 7 under RCRA (1992). Total Estimated Cost: $63,748,000

Table Ex-3. Remedial Alternatives for the Site 300 Operable Units. (Cont. Page 5 of 9)

Remedial Alternatives for Building 850 (OU 5)			
Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
No further action for all contaminants and media of concern. Previous interim actions: 1) Removed PCB-contaminated debris from vicinity of B850 Firing Table (1998). 2) Removed/replaced contaminated gravel from Building 850 Firing Table (1988). Total Estimated Cost: $0	Module B: Monitoring of ground and surface water. Module C: Exposure control through risk and hazard management. Module D: Monitored natural attenuation of tritium in ground water and surface water. Module G: Removal of contaminated sandpile at B850 and removal of contaminated soil adjacent to B850 firing table (partial module G). Previous interim actions: 1) Removed PCB-contaminated debris from vicinity of B850 Firing Table (1998). 2) Removed/replaced contaminated gravel from Building 850 Firing Table (1988). Total Estimated Cost: $4,029,000	Module B: Monitoring of ground and surface water. Module C: Exposure control through risk and hazard management. Module D: Monitored natural attenuation of tritium in ground water and surface water. Module G: Excavation of contaminated soil and bedrock under B850 firing table, removal of contaminated sandpile at B850, and removal of contaminated soil adjacent to B850 firing table. Previous interim actions: 1) Removed PCB-contaminated debris from vicinity of B850 Firing Table (1998). 2) Removed/replaced contaminated gravel from Building 850 Firing Table (1988). Total Estimated Cost: $8,246,000	Module B: Monitoring of ground and surface water. Module C: Exposure control through risk and hazard management. Module D: Monitored natural attenuation of tritium in ground water and surface water. Module E: Ground water extraction and treatment of uranium-238 and nitrate. Module F: Control migration of uranium-238 in ground water using in situ reactive permeable barriers . Module G: Excavation of contaminated soil and bedrock under B850 firing table, removal of contaminated sandpile at B850, and removal of contaminated soil adjacent to B850 firing table. Previous interim actions: 1) Removed PCB-contaminated debris from vicinity of B850 Firing Table (1998). 2) Removed/replaced contaminated gravel from Building 850 Firing Table (1988). Total Estimated Cost: $16,097,000

Table Ex-3. Remedial Alternatives for the Site 300 Operable Units. (Cont. Page 6 of 9)

Remedial Alternatives for the Landfill Pit 2 (OU 5)		
Alternative 1	**Alternative 2**	**Alternative 3**
No further action for all contaminants and media of concern. Previous interim actions: None. Total Estimated Cost: $0	Module B: Monitoring of ground and surface water. Previous interim actions: None. Total Estimated Cost: $515,000	Module B: Monitoring of ground and surface water. Module C: Waste characterization with contingent monitoring, capping or excavation of Pit 2 Previous interim actions: None. Total Estimated Cost Range: $767,000 to $22,250,000

Remedial Alternatives for Building 854 (OU 6)	
Alternative 1	**Alternative 2**
No further action for all contaminants and media of concern. Previous interim actions: 1) Excavated TCE-contaminated soil at Buildings 854H and 854F (1983). Total Estimated Cost: $0	Module A: No further action for metals, HMX, PCBs, and tritium in surface soil. Module B: Monitoring of ground water. Module C: Exposure control through risk and hazard management. Module D: Ground water and soil vapor extraction and treatment of TCE, perchlorate, and nitrate. Previous interim actions: 1) Excavated TCE-contaminated soil at Buildings 854H and 854F (1983). Total Estimated Cost: $9,150,000

Table Ex-3. Remedial Alternatives for the Site 300 Operable Units. (Cont. Page 7 of 9)

Remedial Alternatives for Building 832 Canyon (OU 7)	
Alternative 1	**Alternative 2**
No further action for all contaminants and media of concern. Previous interim actions: None. Total Estimated Cost: $0	Module A: No further action for (1) HMX in surface soil and nitrate in subsurface soil/rock at B830 and (2) HMX in subsurface soil/rock at B832. Module B: Monitoring of ground and surface water. Module C: Exposure control through risk and hazard management. Module D: Ground water and soil vapor extraction and treatment of VOCs, perchlorate, and nitrate at Building 832. Module E: Ground water and soil vapor extraction and treatment of VOCs, perchlorate, and nitrate at Building 830. Module F: Downgradient ground water extraction using siphon with *ex situ* treatment of VOCs by iron filings. Previous interim actions: None. Total Estimated Cost: $26,766,000

Table Ex-3. Remedial Alternatives for the Site 300 Operable Units. (Cont. Page 8 of 9)

Remedial Alternatives for Building 801 and Landfill Pit 8 (OU 8)		
Alternative 1	**Alternative 2**	**Alternative 3**
No further action for all contaminants and media of concern. Previous interim actions: 1) Removed/replaced firing table gravel periodically since 1988. 2) Closed dry well 801D (1981). Total Estimated Cost: $0	Module A: No further action for VOCs in subsurface soil for the B801 dry well. Module B: Monitoring of ground water. Previous interim actions: 1) Removed/replaced firing table gravel periodically since 1988. 2) Closed Dry Well 801D (1981). Total Estimated Cost: $535,000	Module A: No further action for VOCs in subsurface soil for the B801 dry well. Module B: Monitoring of ground water. Module C: Waste characterization with contingent monitoring, capping, and/or excavation of Pit 8. Previous interim actions: 1) Removed/replaced firing table gravel periodically since 1988. 2) Closed Dry Well 801D (1981). Total Estimated Cost Range: $742,000 to $21,612,000

Remedial Alternatives for Building 833 (OU 8)		
Alternative 1	**Alternative 2**	**Alternative 3**
No further action for all contaminants and media of concern. Previous interim actions: None. Total Estimated Cost: $0	Module B: Monitoring of ground water. Module C: Exposure control through risk and hazard management. Previous interim actions: None. Total Estimated Cost: $820,000	Module B: Monitoring of ground water. Module C: Exposure control through risk and hazard management. Module D: Ground water and soil vapor extraction and treatment of VOCs at Building 833. Previous interim actions: None. Total Estimated Cost: $4,256,000

Table Ex-3. Remedial Alternatives for the Site 300 Operable Units. (Cont. Page 9 of 9)

Remedial Alternatives for Building 845 Firing Table and Landfill Pit 9 (OU 8)		
Alternative 1	**Alternative 2**	**Alternative 3**
No further action for all contaminants and media of concern. Previous interim actions: 1) Removed/replaced firing table gravel periodically since 1988. Total Estimated Cost: $0	Module A No further action for HMX and uranium-238 in subsurface soil/rock. Module B: Monitoring of ground and surface water. Previous interim actions: 1) Removed/replaced firing table gravel periodically since 1988. Total Estimated Cost: $488,000	Module A No further action for HMX and uranium-238 in subsurface soil/rock. Module B: Monitoring of ground and surface water. Module C: Waste characterization with contingent monitoring, capping, and/or excavation of Pit 9. Previous interim actions: 1) Removed/replaced firing table gravel periodically since 1988. Total Estimated Cost Range: $693,000 to $7,065,000

Remedial Alternatives for the Building 851 Firing Table (OU 8)		
Alternative 1	**Alternative 2**	**Alternative 3**
No further action for all contaminants and media of concern. Previous interim actions: 1) Removed/replaced firing table gravel periodically since 1988. Total Estimated Cost:	Module A: No further action for VOCs and uranium-238 in subsurface soil/rock and for RDX, metals, and uranium-238 in surface soil. Module B: Monitoring of ground and surface water. Previous interim actions: 1) Removed/replaced firing table gravel periodically since 1988. Total Estimated Cost: $530,000	Module A: No further action for VOCs and uranium-238 in subsurface soil/rock and for RDX, metals, and uranium-238 in surface soil. Module B: Monitoring of ground and surface water. Module C: Ground water extraction and treatment of uranium. Previous interim actions: 1) Removed/replaced firing table gravel periodically since 1988. Total Estimated Cost: $4,198,000